Smart strategies for the transition in coal intensive regions

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1. Introduction

The Silesia Voivodeship authorities have elaborated a development strategy for the region until 2030. The vision behind the elaborated strategy is "Green Silesia 2030". According to this vision, by 2030, Silesia Voivodeship will be a modern European region with a competitive economy as the result of a responsible transformation, providing its inhabitants with development opportunities and offering a high quality of life in a clean environment. The vision of Silesia Voivodeship's development constitutes a basis for formulating the main objectives of the development policy and defines the aspirations and aims of the regional community.

The vision of Silesia Voivodeship's development will lead to creating a region with a new, positive image, which will occupy an important position in the processes of European development. Silesia Voivodeship will be a region creating development opportunities for its inhabitants and providing a sense of public, health and social safety. It will be a region where a modern, innovative and diversified economy, culture and education ensure that it will maintain its position as one of several centres of civilisational development in Poland and Europe. Thanks to the responsible shaping of economic, spatial and environmental policies, the Silesia Voivodeship will be a region of great natural, cultural and landscape values, creating conditions for a healthy and active life in a high-quality environment and ensuring the preservation of biodiversity.

Building the future of the voivodeship involves the use of the existing potentials and values that make the region unique, such as a respect for tradition and local culture, industriousness, strong family ties, hospitality, openness and an ability to cooperate. Building the future assumes also creating new values such as creative and innovative attitudes, and the ability to network. The vision of the voivodeship's development is also built on its spatial conditions, defining the desirable features of the settlement structure and use of space, as well as the formation of internal and external connections.

2.1 Development of the Strategy: Overview of the process

This document is based on the existing documents available on the official platform: "Just Transformation of Silesia" (a detailed list of documents is provided in the reference list).

2.2 Definitions

DIHs	digital innovation hubs (DIHs)
GHG	greenhouse gas
R&D	Research and development
ESCA	European Cluster Analysis Secretariat
GUS	Central Statistical Office
KSSE S.A.	Katowice Special Economic Zone
SMEs	Small and medium-sized enterprises
RES	Renewable energy sources
GDP	Gross Domestic Product
PPO	Entrepreneurial Discovery Process
RSI/RIS	Regional Innovation Strategy
SWOT	Method of strategic analysis based on comparison of strengths, weaknesses, opportunities and threats
WSL UM	Marshal's Office of the Silesia Voivodeship

WSL Silesia Voivodeship

Innovative activities - include all development, financial and commercial activities undertaken by the company, which are to contribute to its innovation.

Innovation - can mean both an action and its result. An innovation is a new or improved product or process (or a combination thereof) that is significantly different from the entity's previous products or processes and has been made available to potential users (product) or put into use by the entity (process).

Smart specialization - is an innovative approach which aims to stimulate national or regional economic growth and employment in Europe in order to identify and develop one's own competitive advantages. Thanks to partnership and a bottom-up approach, smart specialization connects local authorities, academia, business and civil society, working to implement a long-term growth strategy supported by EU funds.

An innovative enterprise - in the field of product innovations and business processes is an enterprise that in the analyzed period introduced to the market at least one product or business process innovation (a new or improved product or a new or improved business process).

Digital transformation - includes the integration of digital technologies by enterprises, such as: Internet of Things (IoT), cloud computing, innovative digital platforms and blockchain technologies.

2. Setting the context

2.1 Regional profile and specialisation

Generating 12.3% of Poland's GDP (data for 2018) and a population of almost 4.6 million, Silesia is one of the economically and demographically strongest regions in Poland, with a well-developed transport network and energy infrastructure. It is the largest urbanised area in Central and Eastern Europe, with the highest average national population density and an urban population ratio of over 77%. Investors are supported by many business environment institutions. More than 2.8 million people of working age and nearly 119,000 students ensure an abundant and varied workforce, and a large and absorbing market. In Silesia there are 38 higher education institutions, which account for 8.5% of the total number of students in the country. The specificity of the region is a well-developed vocational education system. Its economic and scientific potential results from the concentration of enterprises from various sectors of the economy, including the high and medium-high technology sectors and knowledge-intensive services. The advantage of the region is created by many scientific centres with diverse educational, research and development (R&D) competences [1].

The Silesian Voivodeship is characterised by its high share in the creation of the gross domestic product (GDP), second only to that of the Mazowieckie Voivodeship. The region has invariably maintained the position of the second economy in Poland for more than a dozen years, but the lower GDP growth rate that has occurred since 2016 has caused the province to slowly lose its strong position [2]. In 2018, the Silesian region generated 12.3% of the national GDP value, taking the second place after the Warsaw capital region (as it did in 2016–17). In 2018, the value of GDP per capita in the Silesian region was PLN 57,400. The value of GDP per capita of the Silesian region in 2018 was 47.4% of the GDP per capita in the Warsaw capital region, which recorded the highest level of GDP per capita in Poland [3].

The number of unemployed registered in district labour offices in the province of Silesia at the end of October 2021 was 80,460 people. As of 30 September 2021, the unemployment rate in Silesia was 4.5% (5.6% nationally). Of all the provinces in Poland, Silesia has the second lowest value of this indicator, after Wielkopolska (3.3%). However, the intensity of unemployment in the region remains highly varied [4].

The Silesian Voivodeship is among moderately innovative regions [5] and is in 202nd place among European regions. In 2016–18, 28% of industrial enterprises and 16.3% of service enterprises were engaged in innovation. The number of entities conducting R&D activities increased from 528 in 2016 to 622 in 2018, of which, at the end of 2018, 515 were enterprises. In relation to the population potential of the Silesian Voivodeship, this places the region in fifth position in the country. In 2016–18, the total internal expenditure on R&D activities increased in the Silesian Voivodeship by 55.34% (Poland: 42.94%), including in the business sector by 63.39% (Poland: 43.86%), and in higher education by 47.93% (Poland: 44.25%). At the same time, in the sectors of government and private non-commercial institutions, they decreased by 18%.

The assessment of the level of outlays on R&D activities by outlays per capita, per employee in R&D, and in relation to GDP, indicates a weak position of the Silesian Voivodeship in relation to its human and economic potential and in comparison to three other voivodeships in Poland: Dolnośląskie, Małopolskie and Mazowieckie. Between 2016 and 2018, the number of employed lecturers in higher technical schools in the Silesian Voivodeship decreased by 6.6%, and the percentage of students in technical and natural sciences fell by more than 7% [6].

Despite several actions undertaken in the Silesian Voivodeship in 2014–2021 to boost the innovative economy, the level of cooperation between innovating enterprises and the environment is still low. The level of cooperation between enterprises and universities and research institutes is not satisfactory. In the province there is a high saturation of the economy with small, medium and large entities per 10,000 inhabitants. However, the changes in the structure of enterprises and their relatively poor financial condition, measured especially by profitability, capital and asset ratios, are unfavourable. Consequently, the rate of growth of internal expenditure on R&D activities is low in the region (half that of the Polish average), and the accumulation of capital for future development of innovative activity is limited [7].

2.2 Upper Silesia's energy and environment outlook

The National Energy and Climate Plan for 2021–2030 [8] assumes a 7% reduction of greenhouse gas (GHG) emissions in non-ETS sectors compared to 2005 levels; a 21–23% share of renewable energy sources (RES) in gross final energy consumption (the 23% target will be achievable if Poland is granted additional EU funds, including those earmarked for a just transition); a 23% increase in energy efficiency compared to primary energy baseline projections (PRIMES2007); and a 56–60% reduction in the share of coal in electricity generation.

The Silesia Voivodeship, through the implementation of, for example, the provisions of the Territorial Plan of Just Transition (TPJT) [9], will directly contribute to achieving the objectives set out in the document in the area of energy security, lowering carbon dioxide emissions, increasing energy efficiency and development of the R&D sector, which contributes to increasing the level of innovation in the economy. Due to the fact that the Silesian Voivodeship is one of the regions with high levels of both electricity production and consumption (respectively in the 3rd and 2nd position compared to other voivodeships in Poland), the activities undertaken in the area of transformation are necessary to achieve the objectives set out at the national level. Measures implemented in Upper Silesia will include the gradual closing and restructuring of mines and decommissioning of obsolete power plants (built in the 1970s and 1980s), and replacing them with modern, environmentally and socially friendly infrastructure.

It should be pointed out that the phasing out of coal-fired power plants will be in accordance with the schedule developed by the government in consultation with the trade unions and will translate into a level of hard coal extraction that will enable the power sector to meet its demand. According to the information obtained from the Ministry of State Assets, two power plants located in the transformation area are to conclude their operation by 2030, namely Laziska Power Plant by 2028 and Rybnik Power Plant by 2030. Renewable energy

sources will play a key role in the power system. The TPJT provides support for this type of investment as an important element of diversification of generation sources in the regional energy mix. Implementation of the indicated measures will contribute to achieving the national target of a 21–23% share of RES in gross final energy consumption. Implementation of the TPJT will also contribute to the reduction of the emissions level nationally, including the emission of greenhouse gases. One of the main transformational challenges is the improvement of air quality, including the implementation of measures to enable the transition to a zero-carbon economy.

Bearing in mind that the Silesian Voivodship in recent years has been the largest consumer of hard coal in the country (16,460,000 tons in 2019, i.e. 24.1% of national consumption), both in the industrial sector and the municipal and domestic sectors, the activities proposed by the document are also aimed at supporting entrepreneurs and individuals, enabling the replacement of fossil fuels by renewable energy sources. In addition, support for the energy sector in the region is crucial to achieve the climate objectives such as the reduction in the share of coal in electricity production to 50–60% by 2030. According to forecasts made for the Polish Energy Policy up to 2040 [10], coal mining (without coking) will gradually decrease from 59.6 million tons in 2015 to 41.6 million tons in 2030 (a decrease of 30.2%). In connection with the fact that about 80% of hard coal extraction in Poland takes place in Silesia Voivodeship, it may be assumed that the above-mentioned decrease in the extraction of this raw material will affect mainly the coal mining communities located in this region. The reduction in coal processing is connected with a decrease in demand for coal in all sectors of the economy.

Due to the specific character of the Silesian Voivodeship as the largest mining region in the EU, the transformation has a completely different, more difficult, starting point compared to other regions. Therefore, the transformation activities should focus on mitigating the negative socio-economic effects of the process of closing down hard coal mines. Reducing greenhouse gas emissions will be an indirect effect of the transformation activities carried out, while priority will be given to them in the long term. In accordance with the provisions of the Low-Emission Economy Policy for the Silesian Voivodeship, the Regional Energy Policy 2030, which includes an energy balance prepared on the basis of expert analysis, assumes a 28% reduction of hard coal consumption for electricity and heat production. On this basis, it can be assumed that the emission of greenhouse gases as a result of the transformation activities will decrease by a similar percentage. It should be noted that in the case of methane, the Silesian Voivodeship is a leader in its production at the national level, and a reduction in its production by 28% (115,087.84 t/y) at the regional level will result in a 65% reduction in its production at the national level. In the case of carbon dioxide, the implementation of the actions indicated in the document will result in a reduction of emissions by 8,910,043.52 t/y.

The TPJT will also provide complementary support for activities aimed at increasing the level of innovation in the economy, including the development of the R&D sector in the area of regional smart and technological specialties (in accordance with the draft Regional Innovation Strategy of the Silesia Voivodeship 2030 and the Technology Development Programme of the Silesia Voivodeship for 2019–2030). Financial support for the indicated sector will directly contribute to the achievement of the goal set at the national level, i.e. an increase in expenditure on R&D activity in Poland (from 0.75% of GDP in 2011 to 1.7% of GDP in 2020 and 2.5% of GDP in 2030).

The Silesian Voivodeship is an industrialised region with a high level of urbanisation. Both industry and housing have been undergoing a continuous transformation process for more than 20 years. In the period 2021–2030 the demand for solutions supporting energy efficiency in industry, energy-efficient building construction, energy generation from renewable sources and integration of electromobility infrastructure in building infrastructure will continue. This will contribute to the development of new technologies and their implementation by IT companies, manufacturers of RES equipment and systems, service providers for professional energy, as well as companies in the construction sector.

2.3 Upper Silesia's current energy related R&I landscape

R&D and cooperation with enterprises for innovation are an important part of the activities of selected universities operating in the region (Bielsko-Biała University of Technology and Humanities, Częstochowa University of Technology, Silesian University of Technology, University of Silesia in Katowice, University of Economics in Katowice, WSB University, Silesian Medical University in Katowice). They participate in R&D projects, in the implementation of expertise and technical studies and in other activities that foster the development of competencies of current and future employees of enterprises, including those operating within smart specialisations. It is worth mentioning that, in 2019, Silesian University of Technology (as one of 10 universities in Poland) was awarded the status of research university. Therefore, in 2020–26 it will receive a 10% increase in subsidies to strengthen the infrastructural capacity to carry out R&D work in the following areas: computational oncology and personalised medicine, artificial intelligence and data processing, materials of the future, smart cities, mobility of the future, process automation and Industry 4.0, climate and environmental protection, and modern energy.

The group of research institutes operating in Silesia includes, among others, those supervised by the Minister of State Assets (Central Mining Institute, Institute for Chemical Processing of Coal and KOMAG Institute of Mining Technology), those supervised by the Minister of Climate and Environment (Institute for Ecology of Industrial Areas), and a number of institutes of the Polish Academy of Sciences. While the Institute of Welding, the Institute of Ferrous Metallurgy, the Institute of Non-Ferrous Metals, the EMAG Institute of Innovative Techniques, the Institute of Innovative Techniques, the KOMEL Institute of Electrical Drives and Machines, and the Institute of Medical Technology and Apparatus were included in 2019 in the Łukasiewicz Research Network, which is the third largest research network in Europe. The institutes cooperate with each other within the Network in four technological areas: smart mobility, digital transformation, health, and sustainable economy and energy [11]. On the regional level, they cooperate with economic entities within their own networks and clusters.

There is a significant research potential both in terms of conducting analyses and assessments of the environmental impact of industry and searching for solutions in the implementation of innovations, including innovations that will reduce human pressure on the environment in the Silesian Voivodeship. Research units at several universities (Silesian University of Technology, University of Silesia, Częstochowa University of Technology, and University of Technology and Humanities), research institutes (Central Mining Institute, Institute of Ecology of Industrial Areas, Institute of Environmental Engineering of the Polish Academy of Sciences), as well as several clusters (Silesian Cluster of Revitalisation and Environmental Technologies, Silesia Water, the Silesian Ecological Cluster and the Silesian Waste Management Cluster), have been working for years on organisational and technological solutions that favour the implementation of a green economy, not only in the area of the environment, but most of all building the economic potential of the region and implementing the goals of the new Green Silesia 2030 strategy.

The results of the analysis of research and innovation infrastructure in the Silesian Voivodeship, conducted in terms of smart specialisation [12], indicate that the region is dominated by infrastructure present mainly in the areas of green economy and emerging industries, followed by energy and medicine.

Technology parks and business incubators play an important role in the regional innovation system. In Katowice, Euro-Centrum SA offers its services mainly to companies from the new energy and ICT sectors. Technopark Gliwice focuses on the issues of digitisation, especially its industrial applications. The Sosnowiec Science and Technology Park operates in Sosnowiec, while near Bielsko-Biała, at the airport in Kaniów, there is the Bielski Technology Park of Aviation, Entrepreneurship and Innovation. Selected services, characteristic of technology parks, are also provided by "Górnośląska Agencja Przedsiębiorczości i Rozwoju Sp. z o.o." based in Gliwice (medicine, ICT) and operating as part of its ecosystem: Śląskie Centrum Naukowo-Technologiczne Przemysłu Lotniczego Sp. z o.o. and the "Nowe Gliwice"

Education and Business Centre, as well as Bielski Technology Park Aviation, Entrepreneurship and Innovation Sp. z o.o. based in Kaniów (aviation) and Agencja Rozwoju Regionalnego SA based in Bielsko-Biała (ICT, production management technologies). The variety of incubators and technology parks on offer are complemented by the activities of university technology transfer centres that operate at all public universities conducting research activities of importance to the economy. These centres are: Silesian University of Technology, Częstochowa University of Technology, University of Silesia in Katowice, Medical University of Silesia in Katowice, and University of Economics in Katowice.

To fulfil the provisions of the Regional Innovation Strategy for 2013–2020, the regional government created the Silesian Development Fund, a financial institution whose goal is to build a sustainable, long-term financing system for micro-, small and medium-sized enterprises in the Silesian Voivodeship.

Basically, the *strengths* (in terms of SWOT) of the regional research and innovation system include:

- many research centres with diverse research, development and educational competences,
- relatively high expenditure on innovative activities in enterprises and on R&D activities in general,
- a large market of ICT specialists,
- many years of experience in cooperation between scientific units and business institutions within the RIS,
- a large number of accredited research laboratories,
- the functioning of the Silesian Development Fund, and
- a well-established selection of technology parks and other business institutions.

Accordingly, the *weaknesses* (in terms of SWOT) of the regional R&I system are:

- only moderate success in the commercialisation of research results in the international arena, despite a significant increase in internal expenditure on R&D activities in general;
- a low share of enterprises' revenues from the sale of new or improved products in total sales revenues, despite relatively high expenditure on innovative activities in enterprises;
- only moderate readiness of large companies to cooperate with small innovative companies; and
- a limited number of specialists and employee competences appropriate for market transformation.

3. R&I in Energy and Environment: Vision for 2030 & 2050

3.1 Objectives and outcomes

The development strategy "Silesia 2030" defines four strategic objectives for the Silesian Voivodeship:

a) to be a region of responsible economic transformation,

b) to be a resident-friendly region,

c) to be a region with high quality of the environment and open space, and

d) to be an efficiently managed region.

In the field of innovation, the "Regional Innovation Strategy of the Silesia Voivodeship 2030" has been developed. This document states that the Silesia Voivodeship faces the challenge of transforming its economy from an energy-intensive economy based on fossil fuels towards a sustainable, low-carbon, closed-cycle economy. These transformation processes

concern not only the mining and energy sectors, but also other industries. The European Union's “Roadmap to a Closed Cycle Economy for a Cleaner and More Competitive Europe” assumes that the right product policy framework in the Union will make sustainable products, services and business models the norm and will transform consumption patterns to prevent waste in the first place.

The strategy states that the actions already taken by the European Union and the actions planned under the Green Deal policy will particularly affect the economy of the Silesia Voivodeship, including the mining sector, energy sector, sectors related to the production of metals, motor vehicles, trailers and semi-trailers, rubber and plastic products, and the production of electrical equipment, machinery and equipment, in which the voivodeship holds a significant share in national production. At the same time, in the coming years, many entities from the Silesian Voivodeship will be beneficiaries of the Fair Transition Fund. This support will enable productive investments in small and medium-sized enterprises, leading to economic diversification and economic restructuring, investments in the creation of new enterprises, investments in research and innovation activities and supporting the transfer of advanced technologies, investments in the implementation of technologies and infrastructures providing affordable clean energy, in the reduction of greenhouse gas emissions, supporting energy efficiency and energy generation from renewable sources, investments in digitisation and digital connectivity, investments in land regeneration, decontamination, re-naturalisation and land use change projects, and investments in strengthening a closed-loop economy, as well as providing additional training or retraining to employees.

In connection with the planned process of fair economic transformation, the Development Strategy of the Silesian Voivodeship "Silesia 2030" indicates the need to develop the human resources potential in the entities of the higher education system and science with the creation of innovative and creative solutions, including patents and their commercialisation in cooperation with the economic sector, as well as activation and attraction of human resources in the areas of regional and smart specialisation.

Since 2002, the Silesian Ecosystem for Innovation has been developed. It consists of the Marshal's Office of the Silesia Voivodeship and partner institutions such as higher education and science entities, business environment institutions, clusters, the Network of Regional Specialised Observatories, institutions financing the development of enterprises and creating other instruments of financial support, as well as local self-government units and entities dependent on them.

Smart specialisations of the Silesia Voivodeship have been included for the first time in the Regional Innovation Strategy for 2013–2020. They were identified on the basis of the foresight process carried out under the title "Priority technologies for sustainable development of the Silesian Voivodeship" and complementary work related to the preparation of the Technology Development Programme for the Silesian Voivodeship for 2010–2020. At that time, the list of smart specialisations included three areas: energy, medicine, and information and communication technologies. In subsequent years, on the basis of the entrepreneurial discovery process and the mid-term analysis (2018), two new areas of smart specialisation were proposed. This means that currently the smart specialisations of the Silesian Voivodeship comprise: energy, medicine, information and communication technologies, green economy, and emerging industries.

In 2019, the European Commission published a communication on the European Green Deal, with the main goal of the EU achieving climate neutrality by 2050. About PLN 200 billion of EU and national funds will be directed to the national energy and climate transformation until 2030 under various mechanisms. Poland's Energy Policy until 2040 – a strategy for development of the fuel and energy sector (PEP2040) – based on the three pillars of a fair transition, a zero-emissions energy system, and good air quality – is aimed at using the country's economic, raw material, technological and human resources potential, and creating a lever for the development of the economy through the energy sector. A system of distributed power generation will be developed in parallel to large-scale power generation – where zero-emission sources including offshore wind and nuclear power plants will constitute about half

of the installed capacity by 2040. The objectives included in the strategy for the development of the fuel and energy sector, concerning the equitable transformation of coal regions and the processes associated with it, will be the subject of separate strategic and implementation documents at the regional level.

In relation to the implementation of smart grids, it is envisaged that innovative solutions will need to be developed, tested and implemented in terms of, among others, energy storage, bidirectional transmission networks, digital communication systems, and smart control devices. PEP2040 also outlines the essence of the development of an energy-efficient district heating system. By 2030, at least 85% of the district heating / cooling systems with an ordered capacity exceeding 5 MW should meet the criteria of an energy-efficient district heating system. In terms of energy efficiency improvements, hopes are placed on new technologies supporting the achievement of 23% primary energy savings compared to 2007 projections, including in the building sector and the area of mobility.

The National Energy and Climate Plan for 2021–2030 assumes a 7% reduction of GHG emissions in non-ETS sectors compared to 2005 levels, a 21–23% share of RES in gross final energy consumption (the 23% target will be achievable if Poland is granted additional EU funds, including those for a just transition), a 23% increase in energy efficiency compared to PRIMES2007 projections, and a 56–60% reduction of the share of coal in electricity generation. Poland aims to provide adequate funding to accelerate the low-carbon transformation of the energy sector (including mining) as part of the modernisation of the entire economy.

In 2018, a total of 27,273 GWh of electricity was consumed in the Silesian Voivodship, which is 16.3% of the national consumption. The Silesian Province's own production of electricity does not fully cover the region's demand for electricity (the local production covers ca. 91% of the demand). One of the main reasons for the decrease in electricity production in the voivodeship is the ageing infrastructure of thermal power plants. Heat consumption in the Silesian Province in 2018 was 40,844 TJ, which accounted for 9.1% of the national consumption. In recent years, heat consumption in the Silesian Voivodeship has fluctuated with a downward trend. Primary energy production in Poland is based primarily on fossil fuels, i.e., hard coal, lignite, natural gas or oil, from which both electricity and heat are produced.

However, the share of energy from renewable sources in the acquisition of total primary energy increased from 12.12% to 14.31% between 2014 and 2018. Most energy was obtained from solid biofuels (252,821 TJ) and wind energy (46,076 TJ). In total, the share of energy from biofuels (solid, liquid and biogas) accounted for 79% of all energy obtained in 2018 in Poland from RES. For several years there has been a significant increase in power generated by photovoltaic installations. Prosumer energy plays an important role in this context. Of the more than 155,000 RES micro-installations operating in Poland at the end of 2019, more than 99% were photovoltaic installations. The following energy clusters have been established in the Silesian Voivodeship: Brenergia Local Energy System Cluster, "Żywiecka Energia Przyszłości" Energy Cluster, the Mining and Agricultural Energy Cluster of Gierałtowice Municipality, "Friendly Energy" Cluster in Gliwice Poviat, Cieszyn Energy Cluster and "Tarnogórski Klaster Energii Cieplnej".

Looking ahead to 2030, the EU Directive on the promotion of the use of energy from renewable sources requires member states to provide the conditions for renewable energy prosumers to generate renewable energy, including for their own consumption, and to store and sell their surplus of renewable electricity production. The Directive also refers to the possibility for end users to interact within renewable energy communities. With regard to the target to increase energy efficiency by 23%, compared to PRIMES2007 projections by 2030, relevant regulations are under development due to the need to adapt national regulations to the requirements adopted in Directive 2018/2002/EU. The changes are expected to contribute to greater effectiveness in stimulating projects aimed at increasing energy efficiency, including through the implementation of new instruments and expansion of the target group covered by the energy efficiency certificate system.

In the construction sector, Poland is entering a new era, as from 1 January 2021 all new buildings should be nearly zero-energy buildings. Any existing buildings that are extended or modernised after this date must meet the requirements of the so-called Technical Requirements 2021. In addition, the amendment of the Directive on Energy Performance of Buildings and Directive 2012/27/EU on Energy Efficiency (2018) encourages EU member states to stimulate the development of the infrastructure necessary for the smart charging of electric vehicles and the use of car batteries as an energy source. Its aim is also to promote the automation of energy management in buildings by investing in automation and control systems, including self-regulating devices that set temperatures in individual rooms or zones.

The Silesian University of Technology, Częstochowa University of Technology, Central Mining Institute and Institute for Chemical Processing of Coal provide R&D facilities for the energy sector in the Silesian Voivodeship and elsewhere in Poland. Science and Technology Park Euro-Centrum, Ekoenergia Silesia SA and GPP Business Park SA promote energy efficiency and energy-saving solutions in buildings. The ecosystem of the traditional energy industry includes installation suppliers, engineering companies, integrators and service companies, including those dealing with automation, IT and maintenance. The energy-efficient building industry includes a number of small and medium-sized companies in the areas of building materials, building prefabrication technology, and building automation.

In the Silesian Voivodeship, an industrialised region with a high level of urbanisation, both industry and housing sectors have been undergoing a continuous process of transformation for over 20 years. In the period 2021–2030 the demand for solutions supporting energy efficiency in industry, energy-efficient construction, energy generation from RES and integration of electric transport infrastructure in the building of infrastructure is expected to continue. This will contribute to the development of new technologies and their implementation by IT companies, manufacturers of RES equipment and systems, service providers for professional energy, and companies involved in the construction sector.

There is no official vision or strategy of development elaborated for the Silesian Voivodeship for the year 2050. Therefore, it should be assumed that the trends presented in the vision and strategy for the year 2030 will be continued. More concrete forecasts for research and innovation in the energy and environment sectors could be drawn from official documents with a nationwide scope. The development of the energy sector in Poland has been described in the document “Polish Energy Policy until 2040” (Ministerstwo Energii, 2019). In this strategy, hard coal will continue to play an important role in the energy mix. A total departure from hard coal as a source of electricity is not currently planned, although it is planned to increase the importance of renewable energy sources in the energy mix. The directions of actions indicated in the “Polish Energy Policy 2040” emphasise above all the need to improve energy efficiency, increase security of fuel and energy supplies, diversify the structure of electricity generation through the introduction of nuclear power, develop the use of renewable energy sources, develop competitive fuel and energy markets, as well as limit the impact of the energy industry on the environment. To meet the above challenges, it is necessary to build new, as well as modernise and expand, existing power plants and combined heat and power plants across the country.

However, it should be borne in mind that this relatively new document is already somewhat outdated, as the energy policy of the European Union is changing dynamically and, accordingly, this will mean a change in Polish legal regulations and strategies. For instance, the recent agreement between the Polish government and mining trade unions stipulates that all hard coal mines, excluding mines owned by Jastrzębska Spółka Węglowa S.A. as a coking coal producer, they will be closed by 2049. This means that in 2050 only mines extracting coking coal, i.e. the raw material for the production of coke necessary for steel production, will operate in Upper Silesia. There will be no more hard coal mining for energy production. By the year 2050, continuation of activities in the fields of energetic efficiency, energy production and distribution, clean energy, rational management of raw materials and resources, and sustainable transport will result in achieving a low-carbon economy in Silesia.

3.2 Key guiding principles

The key principles determining the implementation of the regional innovation strategy include those set out in the Development Strategy of the Silesian Voivodeship "Silesia 2030", including in particular:

- partnership and cooperation (numerous actors involved on the basis of permanent and conscious relations);
- subsidiarity (each action is programmed and implemented at the lowest possible but effective level);
- thematic concentration (giving priority to the region's areas of smart specialisation);
- intensity of support (concentrating the amount of support for the region's smart specialisation);
- coherence (compliance of strategic and planning documents with national and European programming documents), evidence-based decision-making (conducting policy on the basis of experience, collected data, conclusions, recommendations, evaluation of its effectiveness and prospective analysis);
- flexibility (adapting to emerging opportunities and potential development dynamics, particularly in the process of entrepreneurial discovery);
- conditionality (granting support only when certain conditions are met);
- sustainable development and investment (integrating the social and economic dimensions of development with the least possible pressure on the environment and open space);
- prudence (caution) in relation to the environment (exercising due care in assessing the environmental effects of a newly taken decision or launched activity); and
- prevention in relation to the environment (preventing negative environmental effects at the planning stage).

4. Support framework for R&I in Energy and Environment

4.1 Multi-level governance structure for R&I policies in Upper Silesia

This scope includes the project "Innovative Silesia, Autostrada Firm Przyszłość", included in the Development Strategy of the Silesian Voivodeship "Śląskie 2030" [13]. The project includes:

- investments in highly specialised, integrated industrial and research centres (technology parks in the area of smart specialisation;
- regional network, universities and research centres of universities, R&D centres, research units, research institutes);
- support for the development and cooperation of companies operating in the areas of smart specialisation;
- support and development of the activities of digital innovation hubs (DIHs) operating under the one-stop-stop model;
- support for clusters as a tool for developing cooperation between companies, universities and research institutes;
- support for companies engaged in export activities;

- development of financial and organisational instruments for creating and supporting companies that implement new technologies, and to support high-risk companies; and
- development and comprehensive support of the patent process and its implementation.

4.2 Funding opportunities

The main source of finance for the necessary R&I activities will be the resources of the European Funds for 2021–27, related to the implementation of Objective 1 of the Cohesion Policy. Contributions for project co-financing are to come from the beneficiaries' own funds – possibly as part of financial engineering, supplemented with funds under instruments such as loans, guarantees or venture capital – and from regional and national public funds [14].

It is also expected that as a result of activities undertaken by enterprises and other organisations in the innovation ecosystem of the Silesian Voivodeship, available funds will be used under national Operational Programs and international support programs for the promotion of R&D (Horizon Europe). In order to increase interregional cooperation, including in the context of exchanging good practices and implementing joint investments or establishing scientific and business cooperation, it is planned to promote European support programs [14].

One of the financing mechanisms supporting the implementation of projects related to the Strategy will be funds at the disposal of the Silesian Development Fund. This fund was established in order to build a sustainable, long-term system of financing micro-, small and medium-sized enterprises, as well as local government units in the region, based on repayable financial instruments. It would be advisable for the funds from the feedback tools to be directed to the implementation of the Regional Innovation Strategy and to finance some of its objectives from the moment of implementation [14].

It is also anticipated that the resources available under the Facility for Reconstruction and Increasing Resilience will be able, in part, to finance the objectives of the Strategy, especially in terms of economic transformation and human resource development. In this context, the directions of support were included in the matrix of the intervention rationale of the Regional Plan for a Just Transformation of the Silesian Voivodeship 2030 [14].

4.3 Priority areas for research and innovation

Tables below present major topics which are likely to receive support during implementation of research and innovation strategy in the field of energy in Upper Silesia.

Table 1. Smart specialisation in energy, priority technologies [14]

Technology group	Technology subgroups
Highly efficient energy technologies limiting the emission of greenhouse gases and other pollutants into the environment	- clean coal technologies; - technologies for capturing and storing carbon dioxide; - technologies for the use of waste heat, low-temperature heat and other forms of dissipated energy; - technologies increasing the quality parameters of fuels; - technologies improving the efficiency of energy conversion; - development of pyrolysis and gasification technologies; - technologies for reducing and managing harmful compounds from emissions and by-products from the energy production process

Combined generation – cogeneration and polygeneration	- technologies improving the efficiency of combined energy production; - technologies adapting combined systems to the use of new fuels or fuels of lower quality parameters
Technologies of fuel cell production	- technologies for the production of new or improved fuel cells; - creation of hybrid systems using fuel cells; - technologies for generating electricity using fuel cells for mobile or stationary applications
Generation of energy from renewable sources and improvement of the efficiency of obtaining energy from renewable sources	- innovative technologies increasing the efficiency of the process of converting solar energy into heat or electricity; - technologies aimed at the creation of installations using the heat of water from mine drainage for energy purposes; - new or improved biogas production technologies; - new or improved biomass gasification technologies for energy purposes
Prosumer energy	- technologies aimed at the creation of high-efficiency, small-scale energy conversion and use systems, located near or directly at the site of the user; - technologies aimed at the creation of energy-efficient, cheap and easy-to-use systems enabling the adjustment of the amount of energy produced in micro-sources to the recipient's needs – creation of systems enabling the use of waste energy on a micro scale; - the use of energy storage to support energy management and to provide support services related to the improvement of power quality; - technologies integrating various power supply systems and access to energy carriers on a micro scale; - electricity storage technologies in prosumer systems; - technologies aimed at improving the security of cooperation between micro-sources and low-voltage distribution networks; - development of information technologies in prosumer energy
Technologies of smart grids and interconnections	- electricity demand management methods and algorithms; - intelligent automation, tools and measuring systems in power systems; - integration of power grids, tele-communications networks and IT systems that make up smart power grids; - integration of distributed energy sources and energy storage with the power system;

	- digital measurement systems, including remote metering systems; - development of data transmission techniques and technologies for the needs of the power industry; - software development for the power industry
Energy storage technologies	- heat accumulation technologies in combined heat and power plants; - energy storage with the use of new generation technologies, increasing the safety and efficiency of this process; - technologies that allow the use of excess energy to produce a storage medium (e.g. hydrogen); - new or improved storage technologies for energy carriers; - energy storage technologies with the use of chemical compounds, including heat accumulators; - accumulator and battery manufacturing technologies; - mobile energy storage, including the use of electric vehicle batteries as energy storage in optimising the operation of a smart grid with renewable energy sources; - technologies for the use of energy storage in distributed hybrid systems; - technologies for integrating energy storage with RES installations
Technologies for generating energy from waste and alternative fuels	- technologies for transforming waste into energy; - technologies aimed at the creation and development of installations for the processing of fuels from waste; - technologies for the use of gas from mine methane drainage for energy purposes; - technologies allowing for efficient energy production from diffused methane coming from the ventilation air - technologies for using gas from demethanation of mines for energy purposes; - technologies for the production of liquid or gaseous alternative fuels for energy purposes from biomass or selected waste
Smart and energy-saving construction	- development of technologies increasing the energy efficiency of buildings, in particular improving the insulation of building partitions and increasing the efficiency of heating, cooling, ventilation and air conditioning systems; - installation of devices and energy management systems in buildings to allow for the optimal, automatic and smooth use of multiple power sources;

	- integration of intelligent building systems with prosumer energy service and control systems; - development of intelligent and energy-saving lighting systems

Table 2. Smart specialisation – green economy, priority technologies [14]

Technology group	Technology subgroups
Biotechnologies for environmental protection	-biosorption; - biopreparations, plant protection products; - sewage treatment and water treatment; - biopolymers; - pro-ecological technologies for agriculture; - biotechnological processes in various industries – bioaugmentation; - fuel microcells; - monitoring of wastewater treatment and water treatment processes
Construction technologies	- smart construction; - material recycling; - construction objects of environmental protection infrastructure; - use of innovative materials in the water and sewage industry
Technologies of environmental protection and reclamation, energy, including biogeochemical engineering	- production technologies; - reclamation; - use of rock aggregates from hard coal mining for various reclamation and construction processes;
Technologies for ecological, safe and effective waste management and waste management	- waste collection and segregation; - recycling; - reclamation; - production of fertilisers from waste; - combustion and energy recovery; - waste storage; - waste management
Technologies for processing (purification and separation) of water, collection and treatment of wastewater	- wastewater treatment ; - water purification, including mine water; - water and wastewater transport systems; - waste management; - sanctioning floodplains in post-mining basins as elements supporting water micro-retention
Technologies limiting the emission of pollutants into the atmosphere	- technologies, including production of dust abatement equipment; - gas-cleaning technologies; - gas capture technologies
Technologies supporting environmental management	- environmental management; - environmental information technologies
Environmental technologies of various industries	- environmental technologies of agricultural production and processing; - environmental technologies of the aerospace and machinery industries; - environmental technologies of the automotive industry;

	- capture, storage, sequestration and management of greenhouse gases; - generation of energy from renewable sources; - generation of energy from non-fossil fuels - clean combustion technologies; - technologies for increasing the efficiency of electricity transmission and distribution; - water processing and supply
Sustainable transport technologies	- technologies for the production and storage of alternative fuels for powering vehicles; - technologies for the construction of means of transport using alternative fuels – intelligent transport management systems

4.4 Evaluation and Monitoring

Monitoring of the Regional Innovation Strategy [14] is an element of the monitoring and evaluation system of the Silesian Voivodeship Development Strategy "Silesia 2030".

The responsibility for monitoring and evaluation of the RIS implementation rests with the Board of the Silesian Voivodeship. The unit responsible for monitoring and periodic evaluations will be the Department of Regional Development [14].

The framework programme of evaluation research will be implemented as follows:

- ex ante – 2021,
- during 2026,
- ex post – 2031,
- three thematic evaluations based on current needs.

The department will conduct cyclical and thematic evaluations by commissioning independent expert studies and in the form of consultations with the previously described bodies, which include representatives of the communities that create the regional ecosystem for innovation, i.e. the Steering Committee of the Regional Innovation Strategy and the Silesian Innovation Council [14].

Regional Specialist Observatories will conduct long-term research on groups of companies, the selection and number of which will be indicated by the research methodology developed at the request of the Marshal's Office of the Silesian Voivodeship. The data will be included in the annual reports of the Observatories and will be periodically transferred, in accordance with the methodology, to the Marshal's Office of the Silesian Voivodeship. In this way, the Marshal's Office will have a reliable source of constantly updated knowledge coming directly from enterprises. The conducted research will also significantly support PPO in the region [14].

One of the indicators monitored during the implementation of the Regional Innovation Strategy will be the position of the Silesian Voivodeship in the Regional Innovation Scoreboard ranking. According to the 2019 ranking, the innovative potential of the Silesian Voivodeship was 51.4% of the average value of the European Union's potential. The voivodeship is in the group of moderate innovators and ranked 202nd in the overall ranking [14].

5. Concluding note

In summarising the analysis of data on the research and innovation (R&I) strategy in the field of energy for Upper Silesia, it can be concluded that in 2021–2030, the demand for solutions supporting energy efficiency in industry, energy-efficient construction, energy generation from renewable sources and integration of electric transport infrastructure with building

infrastructure will continue. This will contribute to the development of new technologies and their implementation by IT companies, manufacturers of RES equipment and systems, service providers for the utility power industry, and companies in the construction sector. At this stage, no official vision or development strategy has been prepared for the Silesian Province for the year 2050. Therefore, it should be assumed that the visions and strategies set for 2030 will be continued. The development of the energy sector in Poland is described in the document "Energy Policy of Poland until 2040" (Ministry of Energy, 2019). According to this strategy, hard coal will continue to play an important role in the energy mix.

A complete departure from hard coal as a source of electricity is not currently planned, although it is planned to increase the importance of renewable energy sources in the overall energy mix. The directions of actions indicated in "The Energy Policy of Poland until 2040" emphasise, above all, the necessity of improving energy efficiency, increasing the security of fuel and energy supplies, diversification of the structure of electricity generation through the introduction of nuclear power, development of the use of renewable energy sources, development of competitive fuel and energy markets, as well as limiting the impact of the power generation industry on the environment. To meet the above challenges, it is necessary to build new power plants and thermal power plants, as well as modernise and expand existing plants throughout the country.

It should be remembered, however, that this relatively new document is already somewhat outdated, as the European Union's energy policy is changing dynamically and, consequently, Polish legal regulations and strategies are changing. For example, the recent agreement between the Polish government and mining unions assumes that all hard coal mines will be closed by 2049. This means that in 2050 there will no longer be any active hard coal mining in Upper Silesia.

In the consultations carried out with the inter-assembly groups, via email, telephone contact and face to face at the meeting on 15 December 2021, additional attention was paid to the following aspects:

- the horizon of the energy transition and hard deadlines given the current state of the developing economy seem too sharp;
- the need to differentiate between thermal and coking coal as a strategic raw material for steel production;
- energy security is crucial for the average citizen, but the existing trend and direction of the energy transition is not fully understood. This is a challenge in the perspective of innovation and energy generation from alternative sources;
- consideration of the post-mining landscape as a unique feature of Upper Silesia in the national context, and even in the European context, with an aim to preserve it during the process of revitalisation of post-industrial areas;
- putting more emphasis on research and innovation in the field of alternative energy sources, and the need for better recognition of the region's potential in RES; and
- the need for research and innovation in the use of methane.

6. References

[1] Ewaluacja – Możliwości rozwoju technologicznego województwa śląskiego po roku 2020, Rekomendacje do projektu „Regionalnej Strategii Innowacji Województwa Śląskiego na lata 2021-2027", Główny Instytut Górnictwa, Ecorys Polska sp. z o.o. Raport opracowany na zlecenie Urzędu Marszałkowskiego Województwa Śląskiego, Katowice – Warszawa, 2019

[2] Diagnoza Strategiczna Rozwoju Województwa Śląskiego, Regionalne Centrum Analiz i Planowania Strategicznego, Departament Rozwoju Regionalnego, Urząd Marszałkowski Województwa Śląskiego, Katowice, 2020

[3] Urząd Statystyczny w Katowicach. (2020). Produkt krajowy brutto w regionie1 śląskim w 2018r. https://katowice.stat.gov.pl/opracowania-biezace/opracowania-sygnalne/rachunki-regionalne/produkt-krajowy-brutto-w-regionie-slaskim-w-2018-r-,1,16.html

[4] https://wupkatowice.praca.gov.pl/documents/162604/893121/Informacja%20miesi%C4%99czna/099307f2-84da-4632-a30a-e62dec3c0160

[5] Hugo Hollanders, Nordine Es-Sadki and Iris Merkelbach, Maastricht University (Maastricht Economic and Social Research Institute on Innovation and Technology – MERIT) Regional Innovation Scoreboard 2019, European Union, 2019

[6] Ewaluacja – Możliwości rozwoju technologicznego województwa śląskiego po roku 2020, Rekomendacje do projektu „Regionalnej Strategii Innowacji Województwa Śląskiego na lata 2021-2027", Raport opracowany na zlecenie Urzędu Marszałkowskiego Województwa Śląskiego, Główny Instytut Górnictwa, Ecorys Polska sp. z o.o., Katowice – Warszawa, 2019

[7] Radło, M-J., Mackiewicz, M., Napiórkowski, T., Rudnicka, M., Radło, U., Tomeczek, A., (2019) Możliwości rozwoju innowacyjnego Województwa Śląskiego po roku 2020, Rekomendacje do projektu Regionalnej Strategii Innowacji Województwa Śląskiego na lata 2021-2027, Raport opracowany na zlecenie Urzędu Marszałkowskiego Województwa Śląskiego, SEENDICO, Warszawa-Katowice

[8] Krajowy plan na rzecz energii i klimatu na lata 2021-2030, Ministerstwo Aktywów Państwowych (Wersja 4.1 z dn. 18.12.2019; version 4.1, 18 December 2019)

[9] Regionalny Plan Sprawiedliwej Transformacji Województwa Śląskiego 2030. Urząd Marszałkowski Województwa Śląskiego, March 2021-11-22

[10] Polityka energetyczna Polski do 2040r. - https://www.gov.pl/web/klimat/polityka-energetyczna-polski

[11] Poprawa wydajności infrastruktury badawczej i innowacyjnej w województwie śląskim, Badanie zrealizowane w ramach projektu pt. "Improving Research and Innovation Infrastructure Performance: from Fragmented to Integrated and Sustainable Cooperation" (2019-2023) "INNO-HEIs", GIG, Katowice 2020.

[12] Poprawa wydajności infrastruktury badawczej i innowacyjnej w województwie śląskim, Badanie zrealizowane w ramach projektu pt. "Improving Research and Innovation Infrastructure Performance: from Fragmented to Integrated and Sustainable Cooperation" (2019-2023) "INNO-HEIs", GIG, Katowice 2020.

[13] Województwo Śląskie 2020. Strategia Rozwoju Województwa Śląskiego „Śląskie 2030", Zielone Śląskie. Załącznik do Uchwały nr VI/24/1/2020 Sejmiku Województwa Śląskiego z dnia 19.10.2020.

[14] Województwo Śląskie 2021. Regionalna Strategia Innowacji Województwa Śląskiego 2030 – Inteligentne Śląskie. Uchwała nr 1554/246/VI/2021 Sejmiku Województwa Śląskiego.